MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2018/2019

EEE7216 – ENGINEERING OPTIMIZATION

31 MAY 2019

9:00 A.M. – 12:00 NOON

(3 Hours)

INSTRUCTIONS TO STUDENTS:

1. This question paper consists of **6** pages only (including this page).

2. Attempt ALL **FOUR** questions. All questions carry equal marks (25 marks) and the distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided. Please submit the softcopy of the report generated by Excel Solver as well.

Question 1

(a) Consider the following linear programming (LP) problem:

$$\text{Maximize } z = x_1 + \frac{3}{4}x_2$$

subject to:

$$\begin{aligned} -2x_1 + x_2 &\le 6 \\ 4x_1 + 3x_2 &\le 24 \\ x_1 &\le 4 \\ x_1, x_2 &\ge 0 \end{aligned}$$

Sketch the feasible region of the above problem, then indicate the possible path followed by each iteration of simplex method in solving the problem. Give the optimal solution of the above problem. [6 marks]

(b) Beta Chemicals & Engineering Sdn. Bhd. manufactures three types of chemical substances, namely C.I, C.II and C.III. The production process requires four types of resources: Raw Chemical 1, 2, 3 and 4. Ingredients and selling price in a 10 liters bag of its 4 types of chemical substances, purchase cost of raw chemicals and their available quantities are as follows:

		Resource requirement per unit			
	Selling price per bag ($)	Raw Chemical 1	Raw Chemical 2	Raw Chemical 3	Raw Chemical 4
C.I	30	2	2	1	1
C.II	35	3	0	2	0
C.III	40	3	1	0	2
Daily availability (liters)		300	unlimited	100	75

The company cannot sell more than 50 bags of C.I and more than 20 bags of C.III in the current period.

(i) Formulate a linear programming problem to determine the daily production figures that will enable the company to maximize its profit. [5 marks]

(ii) Use Excel Solver to solve the problem. [5 marks]

(iii) Perform the sensitivity analysis to determine the shadow prices for raw chemicals 1, 2, 3 and 4. Interpret the values of the shadow prices in the context of the problem. [4 marks]

Continued...

(iv) A valuable customer wishes to purchase an additional bag of Chemical substance C.III. He is willing to pay as much as necessary to make it worthwhile for the Beta company to produce this 21st bag. What is the lowest price the Beta company could charge this customer without reducing their profit?

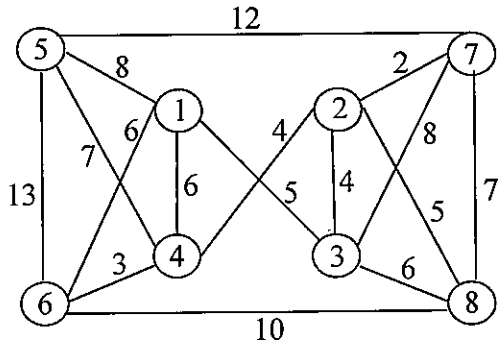
[2 marks]

(v) The supervisor of the Beta company discovered that some of the Raw Chemical 3 are spoiled and cannot be used in the production process. What are the maximum volume of Raw Chemical 3 that can be thrown away before the production line stops their production process? How much do the profits decreased per liter of the discarded Raw Chemical 3?

[3 marks]

Question 2

(a) Consider the following graph:



(i) By using the Kruskal's algorithm, find the minimal spanning tree of the above graph.

[5 marks]

(ii) Give an example of a real life application on how the Kruskal's algorithm can be used to solve the problem.

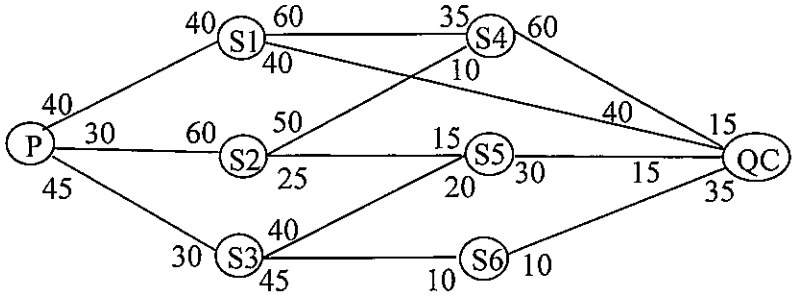
[3 marks]

(iii) State one disadvantage of Kruskal's algorithm, and suggest another algorithm that can overcome the mentioned disadvantage of Kruskal's algorithm and yet can be used to solve the problem as stated in (i).

[2 marks]

Continued...

(b) You as an engineer, who works in an electronic factory, received the new production plan from the company architect. Due to the security reason, the design has the production (P) site separated with the quality checking (QC) site with a single gate leading from P site to the QC site. There are a number of possible routes through the intermediate stations (S1, S2, S3, S4, S5 and S6) within the factory compound to the single QC site. The following network provides the floor plan of the new production plan with the numbers beside the nodes indicate the capacity of the electronics components in thousands of components per hour. For example, the 40 on link from node P to S1 means that the route has a capacity of transferring 40 000 components an hour to node S1. Whereas, the 15 on link from P to S1 means that 15 000 components per hour can move in to node S1.



Your supervisor phoned to say that if the production plan could not accommodate 80,000 components coming into QC site during 1 hour, then the architect should start redesigning. How would you answer the question? Support your answer by providing the complete mathematical model with detailed solution steps to obtain the optimal solution for the current network.

[15 marks]

Continued...

Question 3

(a) Consider the following optimization problem:

The objective is to maximize the function $2x_1+3f(x_2)+5x_3$, with

$$f(x_2)=\begin{cases}5+2x_2, & x_2>0,\\ 0, & x_2=0.\end{cases}$$

The constraints are given as follows:

1. At least two the following inequalities hold:
   $2x_1+3x_2-3x_3\le 10$, $5x_1-3x_2+5x_3\le 15$ and $3x_1+12x_2+8x_3\le 24$.
2. Either one of the following inequalities hold:
   $6x_1+3x_3\le 12$ or $6x_1+2x_2\le 12$.
3. $x_1-2x_2+3x_3=6,9,10$.

(i) Set up the mathematical model that satisfies all of the above requirements. [8 marks]

(ii) Describe a real world application problem that fits to this optimization problem. Provide words description for each of the constraints involved. [5 marks]

(b) Your department has received an order of four jobs, each of which requires processing on the machines. Your department has four machines of different levels of speed. The following table provides the time it would take (in hours) to process any of these jobs on any of the machine:

	Machine			
Jobs	**1**	**2**	**3**	**4**
A	90	5	48	73
B	69	14	83	86
C	57	93	2	79
D	7	77	75	23

By using the branch-and-bound procedure, determine an optimal assignment, with one job to a machine, which will result in a minimum processing time. Use the graph to interpret the branch-and-bound procedure used. [12 marks]

Continued...

Question 4

(a) Use the Golden section method with an error tolerance $\epsilon = 0.05$ and initial bound $x = 0$ and $x = 2$ to approximate the optimal solution of the following problem:

$$\text{Minimize } z = x^3 \sin(2x-3) - 3x, \quad 0 \le x \le 2.$$

[12 marks]

[Hints: $x_1 = x_R - \left(\frac{\sqrt{5}-1}{2}\right)(x_R - x_L)$ and $x_2 = x_L + \left(\frac{\sqrt{5}-1}{2}\right)(x_R - x_L)$.]

(b) Consider the problem

$$\text{Maximize } z = 20x_1 - x_1^2 - 5x_2^2 + 5x_2 - (x_1 + x_2)^2$$
subject to :
$$x_1 + x_2 \le 5,$$
$$x_1, x_2 \ge 0.$$

(i) Rewrite the above problem in separable form.

[4 marks]

(ii) Solve the approximate problem using Excel Solver if the objective function is approximated by piecewise-linear curves with two segments on each curve .

[9 marks]

End of Paper.